— **3219:** Kromrivier (–CB), *Esterhuysen 20518* (BOL).
— **3225:** Bosberg (–DA), *P.T. v.d. W. 363* ? (PRE).
— **3318:** Paarlberg (–DB), *Drège 1276* (P).
— **3319:** Great Winterhoek Peak (–AA), *Galpin 12622* ? (PRE); Baviaansberg (–BA), *Stokoe 4554* (BOL); 'Draakensteensbergen' (–CC), *Drège 7469* (MO; P, photocopy); Stettynsberg (–CD), *Esterhuysen 11154* (BOL).
— **3322:** George: near Klip Drift (–CD), *Fourcade 4716* (BOL–FOURCADE).
— **3319:** Live material from Jonaskop (–DC) was also seen, but no specimens were preserved.

Locality unknown: *A.G.J. s.n. sub MO 1890341* (MO); *Anon. s.n.* (E); *Bernhardi s.n. sub MO 1891418* (MO); 'E seminibus, a Rothio acceptis', *Cohn s.n. sub MEL 94304* (MEL); 'Ex hort. Kil. a . . .', *Mueller s.n. sub MEL 94305* (MEL); 'hort. bot. Hamburg', *Von Winthem s.n. sub MEL 94603* (MEL); Namaqualand, *Scully s.n.* (E).

This species will be described and illustrated in the forthcoming 3rd volume of Van der Walt & Vorster's Pelargoniums of southern Africa.

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A simple relationship for estimating the intensity of fires in natural vegetation

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The response of vegetation to fire depends, among other things, on the intensity of the fire. Estimates of fire intensity are not often included in fire reports as they are difficult to obtain. Fire intensity is closely correlated with flame length which is relatively easy to measure. Data from fires in fynbos are used to illustrate this relationship. The relationship should be useful for estimating fire intensity where better estimates are not possible.

Die reaksie van plantegroei op brand hang onder andere van die intensiteit van die brand af. Aangesien dit moeilik bekombaar is, word beramings van brandintensiteit nie dikwels in verslae ingesluit nie. Brandintensiteit is ten nouste gekorreleer met vlamlengte wat relatief maklik meetbaar is. Data van brande in fynbos word gebruik om hierdie verwantskap te illustreer. Die verwantskap behoort nuttig te wees by beraming van brandintensiteit waar beter beramings nie moontlik is nie.

Keywords: Fire behaviour, fire intensity, fynbos

Fire behaviour is defined as the manner in which a fire reacts to the variables of fuel, weather and topography (Chandler *et al.* 1983), and includes parameters such as flame length, rate of spread and intensity. There is little doubt that the effects of fire on vegetation are greatly dependent on fire behaviour characteristics. Many authors have stressed the importance of including accurate descriptions of fire behaviour in reports on fire effects (McArthur & Cheney 1966; Gill & Groves 1981; Hobbs & Gimingham 1984; Van Wilgen *et al.* 1985). Until recently, few reports on the effects of fire in South African vegetation have included descriptions of fire behaviour, which reduces the value of such reports. Fire intensity is an important fire behaviour parameter that should be used to describe fires (Trollope 1981). There are a number of measures describing fire intensity, and Alexander (1982) gives a good review of these. They include reaction intensity, total heat release and fireline intensity. Reaction intensity, measured in kJ m^{-2} s^{-1}, describes the rate of energy release per unit area in the active combustion zone. Total heat release, measured in kJ m^{-2}, is simply a reflection of the total fuel consumed. Fireline intensity was defined by Byram (1959) as $I = Hwr$ where I is the fireline intensity (kJ m^{-1} s^{-1} or kW m^{-1}), H is the heat yield of the fuel (kJ g^{-1}), w is the weight of available fuel (g m^{-2}) and r is the rate of fire spread (m s^{-1}).

Byram's fireline intensity has been called the 'single most valid characteristic of a fire's general behaviour and direct impact on above-ground vegetation' (Alexander 1982). The measurement of fireline intensity is time-consuming and is not often attempted by researchers due to the amount of work involved. However, fireline intensity is directly related to

flame length (Chandler *et al.* 1983). Byram (quoted by Chandler *et al.* 1983) determined an empirical relationship between flame length and fireline intensity as follows:

$$I = 273\ (h)^{2,17}$$

where I is the intensity in kW m^{-1}, and h is the flame length in metres.

Van Wilgen *et al.* (1985) recorded flame length and determined fireline intensity at 14 experimental fires in fynbos vegetation. These data were used to determine the relationship between flame length and fireline intensity. A regression equation fitted to these data gave:

$$I = 402\ (h)^{1,95},\ r^2 = 0,87$$

The similarity between the model derived from the data of Van Wilgen *et al.* (1985) and that of Byram is shown in Figure 1.

Fireline intensity estimates should be included in reports

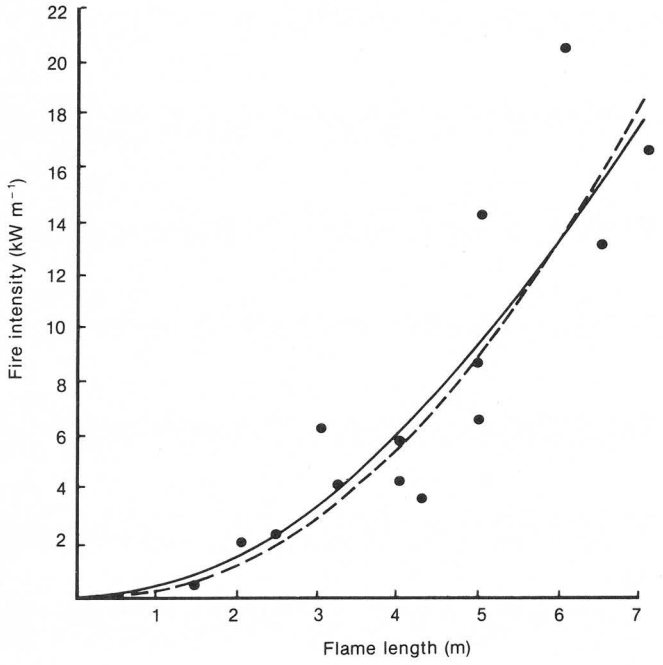

Figure 1 The empirical relationship between flame length and fireline intensity determined in two seperate studies. The lines are: (——) $I = 402\ h^{1,95}$ (Van Wilgen *et al.* 1985) and (– – – –) $I = 273\ h^{2,17}$ (Byram, in Chandler *et al.* 1983), where I is the fireline intensity in kW m^{-1} and h is the flame length in metres.

on the effects of fire so that these can be properly interpreted. Fireline intensity in fynbos vegetation can vary up to three orders of magnitude (from about 200 to 20 000 kW m^{-1}) (Van Wilgen *et al.* 1985), and estimates of intensity from flame length will provide figures that approximate fire intensity within acceptable limits, given the wide range that occurs. Flame lengths can be estimated from photographs of a fire if an object of known length provides scale. Photographs

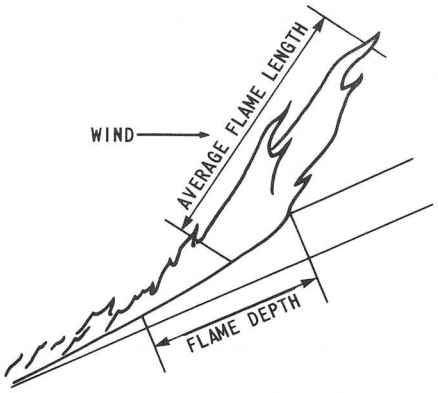

Figure 2 Flame dimensions shown for a wind-driven fire on a slope (after Rothermel and Deeming 1980).

should be supplemented by visual estimates. The real difficulty is identifying the dimension that represents flame length (Rothermel & Deeming 1980). Flame length (Figure 2) is the distance between the tip of the flame and the ground (or surface of the remaining fuel) midway in the zone of active flaming. Because the flame tip is a very unsteady reference, estimates of average length over a reasonable time period are required.

Where the accurate determination of fireline intensity is not possible, researchers should use the above relationship to estimate fireline intensity, and such estimates should be included in reports on the effects of fire on vegetation in South Africa wherever possible. This will facilitate the comparison of the response of vegetation to different fires and it will allow for better interpretation of such responses.

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